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Convair Aerospace Division

A2136-1 (Rev. 1-71)

Final Report

REAL TIME DUST FALL MONITOR
(RTDFM)

Contract NAS 8-31682

Submitted to

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
(NASA/MSFC)

Prepared by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the design and development of a real time dust fall monitor. The instrument is a U.V. optical instrument designed to monitor 300 level surface cleanliness and is intended to be a part of the Integrated Environmental Contamination Monitor (IECM) for Shuttle. The work was funded under MSFC Contract NAS 8-31682.

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SECTION 1

SUMMARY

Contract NAS 8-31682 was awarded to design and develop a laboratory prototype Real Time Dust Fall Monitor (RTDFM). This contracted effort was begun in December 1975 and completed in October 1976. A prototype instrument was designed, built and tested with various configurations of the detector array and sample surface. The design goals for the important parameters size, weight, sensitivity and simplicity were satisfied. A singular but equally important design goal for long term stability was not achieved. Long term instrument stability while a difficult problem could be achieved with further development. Tests run at the end of the program after all funding had been expended indicated that the drift is due to effective lamp intensity variations. A lamp intensity monitor properly temperature compensated could be used to null out the drift due to effective lamp intensity variation.

SECTION 2

DESIGN

Our work in the area of ultra low level light scattering measurements from optical surfaces and NASC/MSFC requirements for a dust monitor for shuttle led to the initial design configuration. This configuration was submitted to MSFC in the form of a planning document CM 75-2004 and an unsolicited proposal CM 75-2004, Revision A. An initial review of the design goals and the proposed configuration pointed out two weaknesses which could be corrected with a modified optical configuration. It should be kept in mind that this effort was conducted on a minimum cost laboratory demonstration of the principle basis.

Parameter	Design Value
Sample Area	232 cm^2 (36 in^2)
Dust Cross Sectioned Area	2.32×10^{-3} cm^2
Number of Standard Particles	30
Standard Material	Sugar Crystals
Signal-to-Noise	10
Short Term Drift $0 < T < 10$ min	3 equivalent particles
Long Term Drift 10 min $< TZ <$ 24 hr	6 equivalent particles
Size L x W x L	22 cm x 18 cm x 18 cm
Weight	$<$ 4 Kg
Power Consumption	$<$ 12 watts
Reproduction Cost	$<$ 800 manhours

TABLE 1. RTDFM DESIGN GOAL SPECIFICATIONS

2.1 DESIGN GOALS

The basic goal of the program was to demonstrate that a surface of level 300 cleanliness could be discriminated from a clean surface with sufficient signal-to-noise. Qualitative values had to be established for the above statement which could be readily measured to determine instrument performance. Level 300 cleanliness was restricted to the definition of 10^{-5} area coverage by 100 micron diameter particles. Collecting surface area is 232 cm^2 (15.24 cm x 15.24 cm)(6 in x 6 in), and surface coverage is $2.32 \times 10^{-3} cm^2$. The standard 100 micron particles have a cross sectional area $7.854 \times 10^{-5} cm^2$ thus 30 such particles on the collecting plate would constitute level 300 cleanliness. The design signal-to-noise goal was then established to be signal to noise equals 10 with 30 standard particles randomly scattered about the sample surface area. These particles were further standardized to be sugar crystals for most of the comparative testing. The remaining design parameters were the physical parameters which do not require explanation and are tabulated in Table 1.

2.2 INSTRUMENT MECHANICAL DESIGN

The RTDFM as proposed is shown in Figures 1 and 2. This design configuration was reviewed at the onset of the program and while it is the ultimate in simplicity, it has two significant deficiencies. First, it is impossible to get a uniform distribution of intensity across the sample area. Secondly, the detector does not have a uniform field of view to all areas on the sample surface. These characteristics would result in nonuniform response depending on the physical location of a dust particle on the sample surface. These deficiencies were considered to be significant enough to warrant modification of the configuration. Uniform illumination could be best obtained by utilizing two sources located equal optical distance from either edge of the sample surface.

Uniform field-of-view to all points on the sample surface area is best obtained by locating a large area detector immediately below the

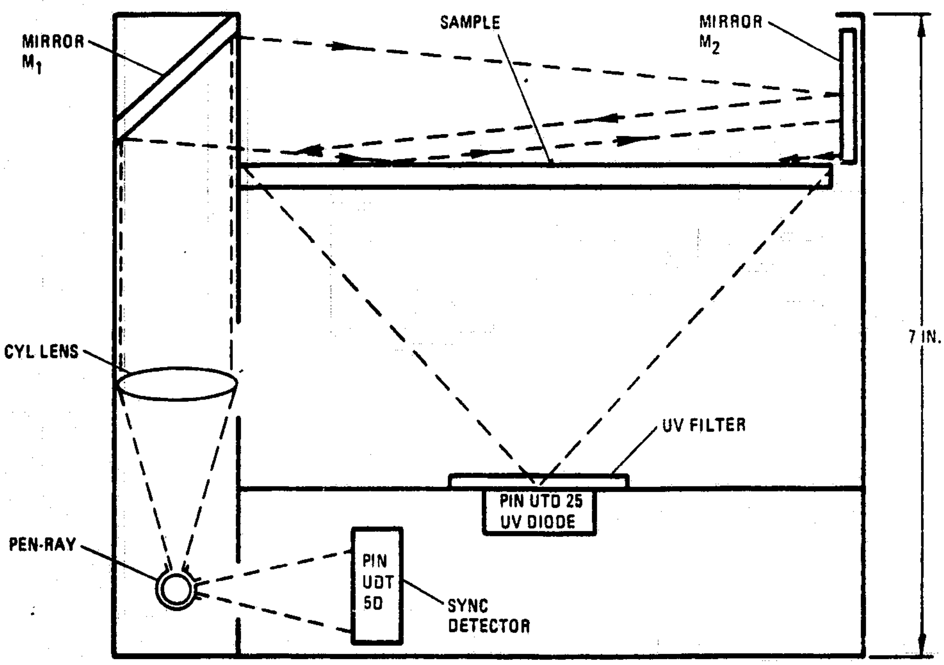


FIGURE 1. SIDE VEIW OF PROPOSED CONFIGURATION

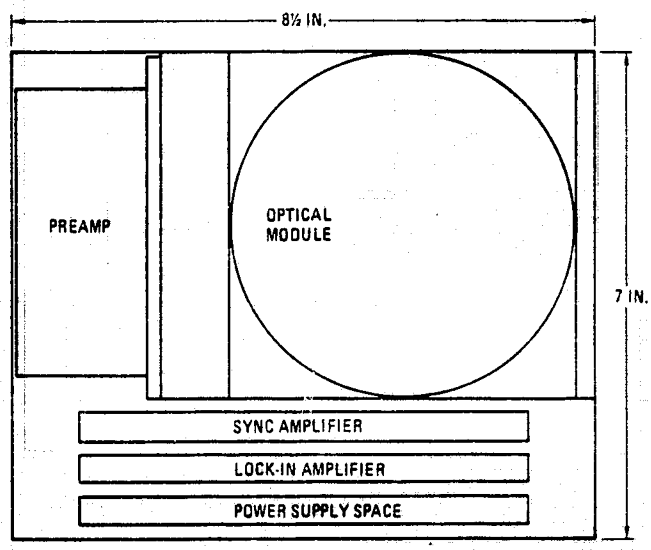
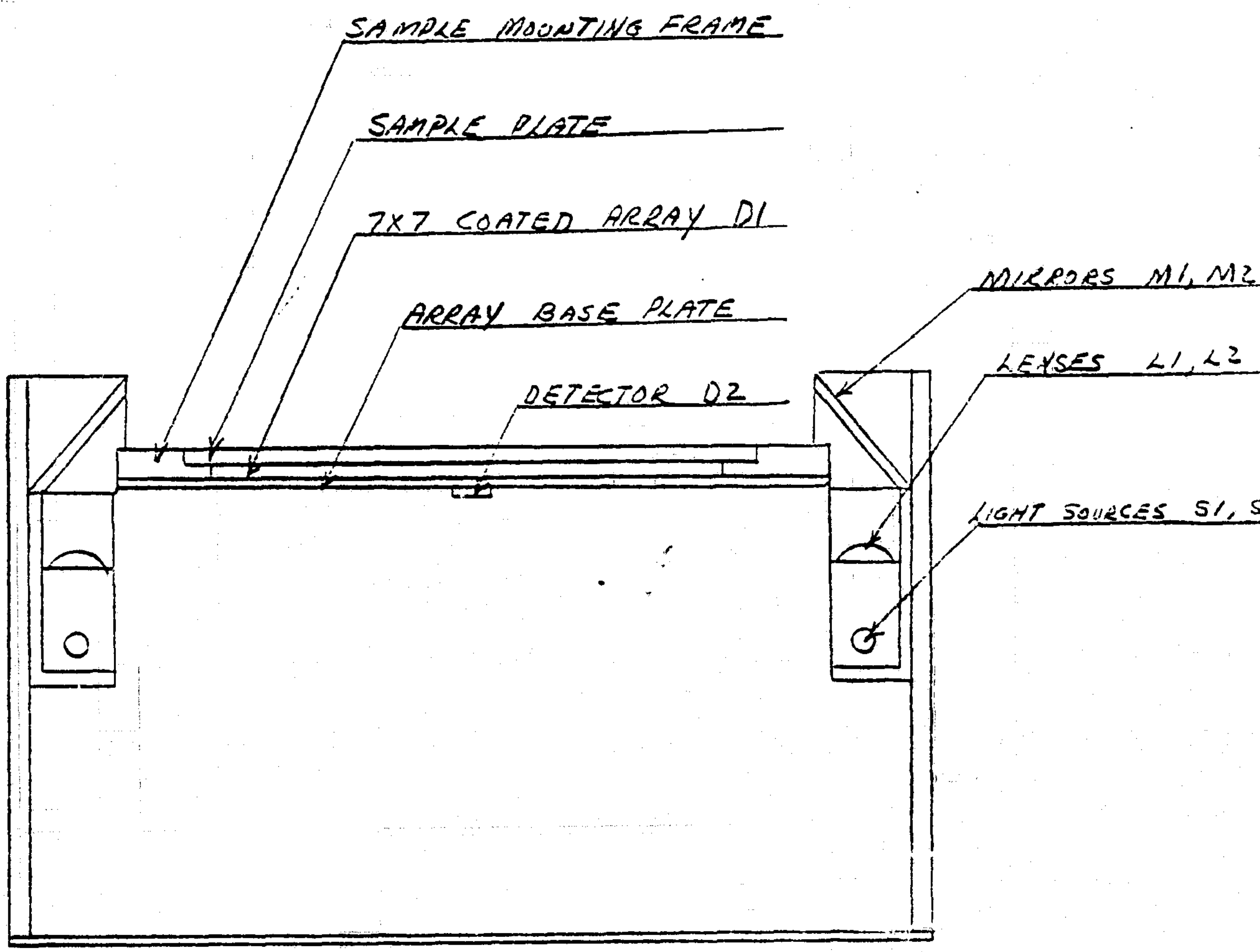


FIGURE 2. TOP VIEW OF PROPOSED CONFIGURATION

sample plate. As the sample area is 232 cm^2, a very large area detector is required. After extensive consideration and testing a solar cell array was selected. These changes to the optical design altered the mechanical configuration to that shown in Drawing 621-76-100, attached as Appendix D. Physical dimensions of the RTDFM are 17.0 x 24.7 x 15.0 cm not including the nylon caps necessary to cover the excessively long U.V. lamps used because they were readily available. Including the nylon protective caps for the lamps, the dimensions are 22.5 x 24.7 x 15.0 cm. These dimensions result in less total volume without the caps (6300 cm^3) than the design goal of 7130 cm^3. The dimensions of the external lamp power supply are 10.5 x 16 x 8.0 cm (1344 cm^3) as shown in Figure 5. The inclusion of this power supply and all other power supplies into the RTDFM would add approximately 1000 cm^3 resulting in a total volume of approximately 7300 cm^3. The laboratory demonstration RTDFM weighs 4.2 Kg and the external lamp supply weighs .91 Kg for a total of 5.11 Kgs. This compares to a design goal of 4.0 Kgs; however, no consideration was given to weight in this design. Cutting away the unnecessary weight while making provisions for the addition of power supplies would result in a fully configured RTDFM weighing approximately 5 Kg.

2.3 OPTICAL DESIGN

Figure 3 below illustrates the optical design of the RTDFM. Light sources S1 and S2 are six inch Pen Ray lamps which emit 90% of their energy at 2537A°. They are syncronously modulated 100% at 1000 HZ and the light is collimated in the axis of the plane of the page by the cylindrical lenses L1 and L2. The parallel beams are reflected by mirrors M1 and M2 onto the sample plate at a 4° angle of incidence. This low angle of incidence combined with the fact that the underside of the sample plate is coated with 500A° of silver insures that less than .001% of the incident energy is transmitted. Coating the sample plate with 500A° of silver also serves to block background visible light. Transmission is less than .005%



RTDFM OPTICAL DESIGN

FIGURE 3

thereby preventing background light from saturating the detector. The sample plates are of selected high quality quartz with low bubble content. This prevents internal scattering which would add to the background and undesirable signal.

Dust particles on the surface scatter the incident 2537A° light at high angles of incidence enabling it to be transmitted through the plate. Specifically, transmission is 42% at 90° and decreases to 18% at 30° angle of incidence. This scattered light along with the transmitted light falls on a 7 x 7 array D1 of coated solar cells. The array is assembled from 2 x 2 cm solar cells (Spectrolab type 4251) which are closely spaced resulting in a 14.2 x 14.2 cm array. The cells are coated with a fluorescent paint DAZ-L No. 842 solar yellow which converts the 2537A° incident energy to visible yellow where the cells have high responsivity. A second detector D2 is located below the array looking into the RTDFM through a neutral density screen type filter. The light falling on D2 is a combination of approximately equal parts from S1 and S2 and is used to monitor lamp intensity. The amplified output of D2 is used for two purposes. First, it offsets the output to cancel that component of the output which is due to the directly transmitted light falling on the array D1. Secondly, by monitoring the source intensity, its output can be used to compensate for output drift due to lamp intensity variations.

2.4 ELECTRONIC DESIGN

The electronics design is described at a functional block level as illustrated below in Figure 4. Individual circuit schematics are included as Appendix A. All circuitry with the exception of the lamp driver amplifier are located on three circuit boards. Component layout of these three circuit boards is included as Appendix B. Location of these boards in the RTDFM is shown in Drawing No. 621-76-100. The lamp driver amplifier requires heat sinking and is therefore fastened to the bottom plate of the instrument.

A 1000 Hz sine wave oscillator output is squared and used to drive the sync generator and a divider. The divider output (drive signal) is a

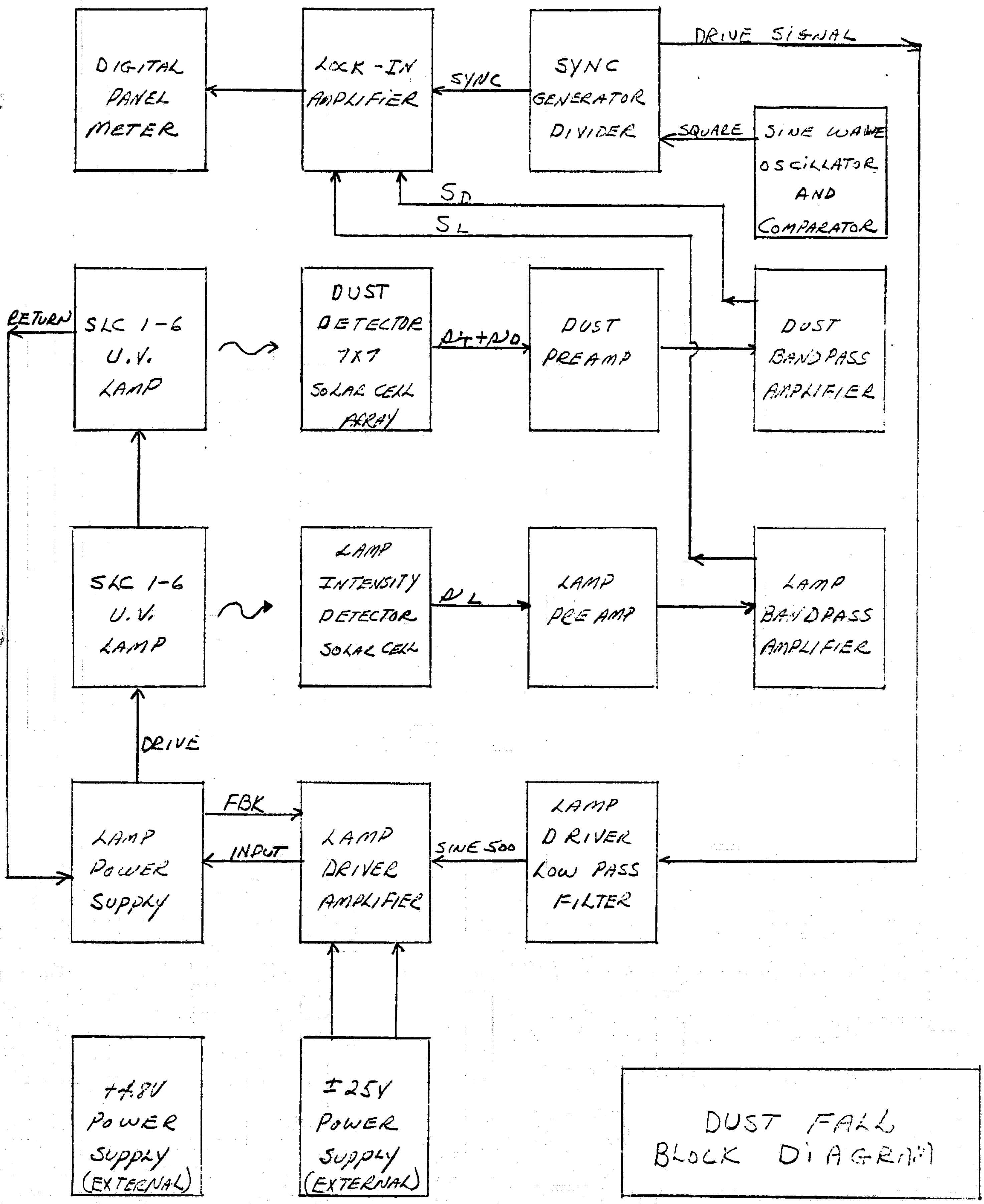

DIGITAL PANEL METER
LOCK-IN AMPLIFIER
SYNC
SYNC GENERATOR DIVIDER
DRIVE SIGNAL
SQUARE
SINE WAVE OSCILLATOR AND COMPARATOR
SD
SL
RETURN
SLC 1-6 U.V. LAMP
DUST DETECTOR 7X7 SOLAR CELL ARRAY
ΔT+ΔD
DUST PREAMP
DUST BANDPASS AMPLIFIER
SLC 1-6 U.V. LAMP
LAMP INTENSITY DETECTOR SOLAR CELL
ΔL
LAMP PREAMP
LAMP BANDPASS AMPLIFIER
DRIVE
FBK
INPUT
SINE 500
LAMP POWER SUPPLY
LAMP DRIVER AMPLIFIER
LAMP DRIVER LOW PASS FILTER
+4.8V POWER SUPPLY (EXTERNAL)
±25V POWER SUPPLY (EXTERNAL)
DUST FALL BLOCK DIAGRAM

FIGURE 4

500 Hz square wave which is put through a low pass filter to obtain a 500 Hz sine wave (Sine 500). This signal is amplified in the lamp driver amplifier and becomes the input to the lamp power supply (input). The lamp power supply is essentially a transformer to produce the 2500 plus volts (DRIVE) required to fire the two SLC1-6 tubes operating in series. Stabilization of the lamp power supply required both voltage feedback (FBK) and an internal current feedback. The lamps which are driven at 500 Hz fire on both half cycles producing a 1000 Hz, 100% modulated light. The detector array detects both the directly transmitted (s_T) and scattered components (s_L) of the incident light. These are amplified in a preamp and bandpass amplifier with center frequency equal to 1000 Hz to produce a signal (S_D). The lamps are also directly viewed by the lamp intensity detector whose output (s_L) is amplified in a preamp and bandpass amplifier identical to the array channel producing a signal (S_L). Internal to the lock-in amplifier the 180° out of phase components, S_D and S_L are added to produce the lock-in amplifier input. Thus for zero dust the input signal to the lock-in is minimum. Dust accumulating on the surface increases the signal S_D resulting in a net positive input to the lock-in and hence a positive going output on the D.P.M. Making S_D equal to $-S_L$ further implied that variation in the lamp intensity will result in no change in the output provided gains and temperature coefficients are matched in the two signal channels.

Total power consumed by the laboratory demonstration unit of the RTDFM is 22.5 watts. Power now consumed by such items as the digital panel meter (2.5 watts), $\pm$15V zener supplies (4 watts) and 6 inch lamp instead of 5 inch lamps (2.5 watts) would not be required of a flight configured package. It is estimated that 14 watts would be required for continuous flight operation.

SECTION 3

FLIGHT CONFIGURATION REQUIREMENT

The laboratory demonstration RTDFM effort did not attempt to package the unit in a flight configuration. Making the RTDFM suitable for flight would require some additional effort. The external ± 25 VDC and + 4.8 VDC power supplies would need to be incorporated into the instrument. It is presumed that + 28 VDC would be the only power available and that a D.C. to D.C. converter would be required to supply the required voltages and to provide power ground isolation. Circuitry would require flight parts and printed circuit board work consistent with flight hardware. A provision would have to be made to hold the sample plates rigidly in place. Holes would be drilled into the sides of the plates and they would be pinned in place through the housing. Finally, the long term drift problem of the instrument would have to be resolved. This requires matching the temperature coefficients of the detector array and the lamp intensity detector as well as the use of low temperature coefficient electronic components in the preamplifiers and band-pass amplifiers. None of these problems represent a great deal of difficulty or an extensive manhour task.

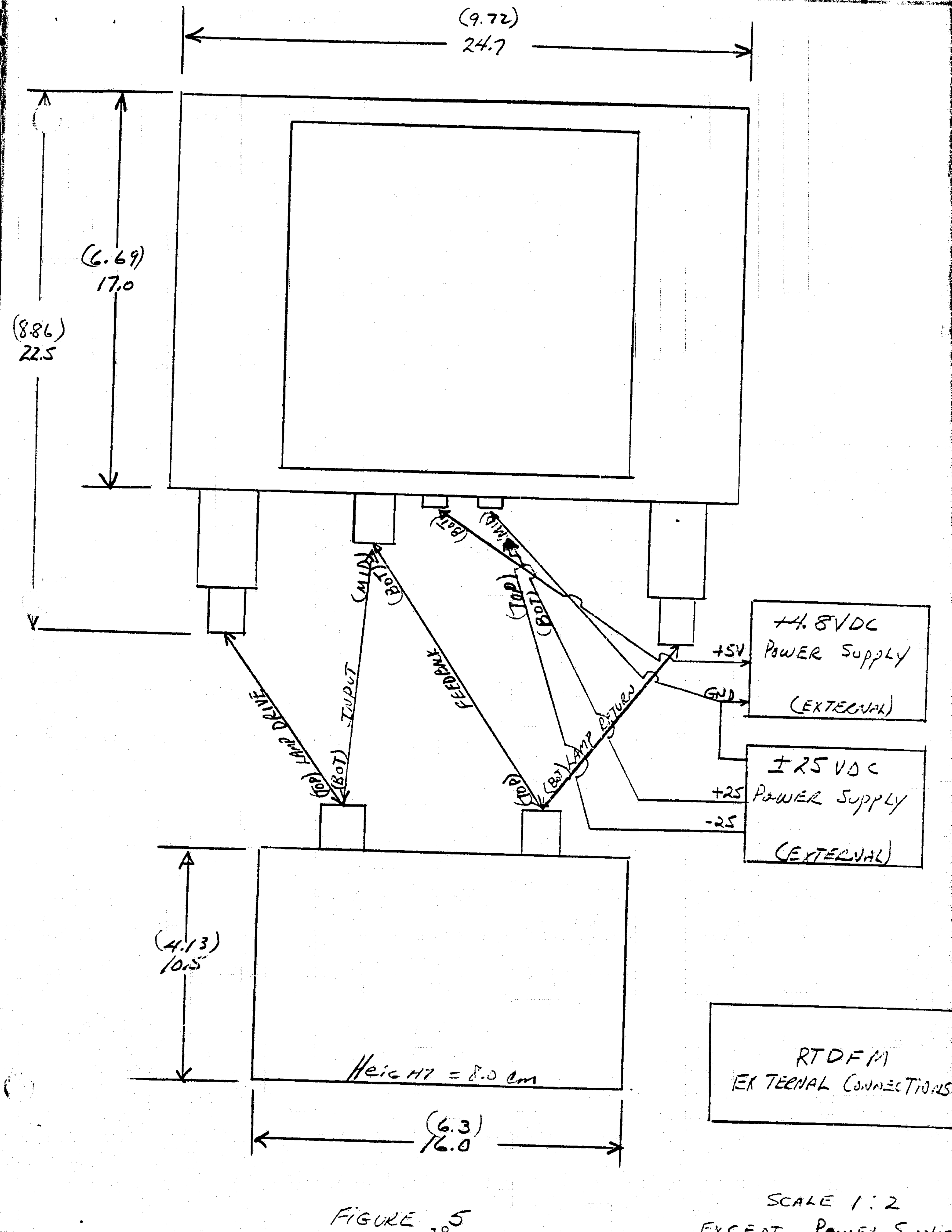
SECTION 4.0

INSTRUMENT OPERATION

RTDFM is very simple to operate. It requires only the interconnection of the external power supplies to the instrument and the application of power. Referring to Figures 5 and 6 and the instrument labels, the following step-by-step procedure should be followed to initially power up the RTDFM.

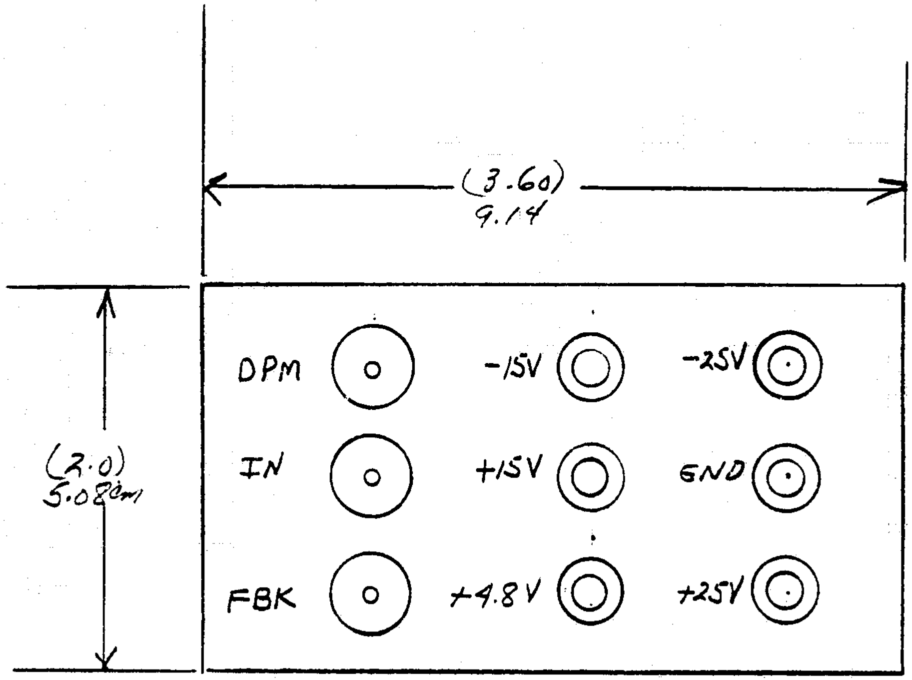
1. Set up EXTERNAL POWER SUPPLIES.
   - A. Set a well regulated ($\pm$ .01 VDC) power supply to 4.80 volts.
   - B. Set a power supply to + 25 VDC.
   - C. Set a power supply to - 25 VDC.
   - D. Turn off power supplies.
2. MAKE REQUIRED INTERCONNECTIONS
   - A. Interconnect all three power suppy commons together.
   - B. Connect power supply common to "GND" jack on the external connection panel.
   - C. Connect + 4.8 V power supply to "4.8 V" jack on the external connection panel.
   - D. Connect + 25 V power supply to "25 V" jack on the external connection panel.
   - E. Connect - 25 V power supply to "- 25 V" jack on the external connection panel.
   - F. Using a short (< 18") coax cable interconnect "FBK" BNC on the interconnection panel to "FEEDBACK" BNC on the lamp power supply.
   - G. Using a short (< 18") coax cable interconnect "IN" BNC on the interconnection panel to "INPUT" BNC on the lamp power supply.
   - H. Using a short (< 18") coax cable interconnect "LAMP DRIVE" BNC on the lamp power supply to the "DRIVE" BNC on the RTDFM.
   - I. Using a short (< 18") coax cable interconnect "LAMP RETURN" BNC on the lamp power supply to the "RETURN" BNC on the RTDFM.

3. CAUTION: Do not make any connections to the "15 V" or "-15 V" jacks on the external connection panel. These are internally generated voltage test points.
4. Turn on the ± 25 V power supplies.
5. Turn on the + 4.8 V power supply.
6. Lamps will arc intermittently for approximately 5 minutes and then begin to stabilize.
7. Let instrument warm up and stabilize for about 30 minutes.
8. RTDFM is now ready to test.
9. NOTE: Best results are obtained in the absence of overhead fluorescent lighting.



(9.72)
24.7
(6.69)
17.0
(8.86)
22.5
(MID)
(BOT)
(BOT)
(MID)
(TOP)
(BOT)
LAMP DRIVE
INPUT
FEEDBACK
LAMP RETURN
(TOP)
(BOT)
(TOP)
(BOT)
+4.8VDC
POWER SUPPLY
(EXTERNAL)
+5V
GND
±25 VDC
POWER SUPPLY
(EXTERNAL)
+25
-25
(4.13)
10.5
HEIGHT = 8.0 cm
(6.3)
16.0
RTDFM
EXTERNAL CONNECTIONS
SCALE 1:2
EXCEPT POWER SUPPLIES

FIGURE 5



NOTATIONS:

DPM - UNFILTED OUTPUT
IN - INPUT TO LAMP POWER SUPPLY
FBK - FEED BACK FROM LAMP POWER SUPPLY
-15V - INTERNALLY GENERATED -15V TEST POINT
+15V - INTERNALLY GENERATED +15V TEST POINT
+4.8V - INPUT FROM EXTERNAL SUPPLY +5.0V
-25V - INPUT FROM EXTERNAL SUPPLY -25.0V
GND - POWER SUPPLY GROUND COMMON TO ALL SUPPLY VOLTAGES
+25V - INPUT FROM EXTERNAL SUPPLY +25.0V

RTDFM

EXTERNAL CONNECTION PANEL

FIGURE 6

SCALE 1:1

SECTION 5

TEST RESULTS

There are three parameters of primary importance in evaluating the instrument. They are the instrument sensitivity, repeatability, and stability.

5.1 SENSITIVITY

Sensitivity is defined to be the difference in output reading from a clean surface to a contaminated surface divided by the number of particles on the contaminated surface. It is further defined to be the statistical average of the above when the particles are sugar crystals of average diameter equal to 100 microns. Table 2 below is an example of actual data taken to determine the RTDFM sensitivity. The data included in Table 2 shows that the sensitivity is 8.11 particles/unit.

CLEAN	CONTAMINATED	NO. PARTICLES	PARTICLES/UNIT
746	753	40	5.71
746	749	17	5.67
746	748	13	6.50
747	752	44	8.80
747	750	27	9.00
747	749	17	8.50
746	749	18	6.00
745	749	28	7.00
745	748	21	7.00
745	750	48	9.60
745	749	39	9.75
745	746	7	7.00
745	749	37	9.25
745	748	24	8.00
745	746	12	12.00
745	748	30	10.00

$$\text{Sensitivity} = \sum \frac{\text{Particles/Unit}}{N} = \frac{129.78}{16} = 8.11 \quad \text{Particles/Unit}$$

TABLE 2. SENSITIVITY DATA

5.2 REPEATABILITY

Repeatability is defined to be the average percent change in sensitivity from the mean sensitivity when the particles forming a fixed level of contamination are randomly rearranged. Table 3 below tabulates the data used to determine the repeatability. The data included in Table 3 shows that the repeatability is ± 5.5%.

READING (1)	READING (2)	NO. PARTICLES	PARTICLES/UNIT	%
749	756	31	3.44	10.9
755	756	31	3.44	10.9
756	755	31	3.88	.5
755	756	31	3.44	10.9
756	754	31	4.43	14.8
754	754	31	4.43	14.8
754	755	31	3.88	.5
755	755	31	3.88	.5
755	755	31	3.88	.5
755	755	31	3.88	.5
755	755	31	3.88	.5
755	747	0	3.88	.5

$$\text{Mean Sensitivity} = \sum \frac{\text{Particles/Unit}}{N} = \frac{46.34}{12} = 3.86$$

$$\text{Mean Repeatability} = \frac{\sum \%}{N} = \frac{65.8}{12} = 5.5\%$$

TABLE 3. REPEATABILITY DATA

5.3 STABILITY

Stability is defined as the total indicated change in 100 micron particle count over a 24-hour period of time with a constant level of contamination. The data in Table 4 below was used to determine that the laboratory demonstration unit has stability equal to 35 particles/hour. This instability is attributed almost exclusively to the difference in temperature coefficients in the lamp intensity and dust data channels. It is estimated that matching these temperature coefficients would reduce the instability to less than 5 particles/day. This fact was established by analyzing long term stability tests of the output voltages of the dust and lamp bandpass amplifier. This test and a number of other tests on second level or significance parameters were conducted. While qualitative data on the primary parameters is reported above, the results of other testing is limited to the following series of quantitive statements.

Lack of long term stability is due to differences in the temperature coefficient of responsivity from detector through bandpass amplifier of the lamp intensity and dust channels.

Solar cells operating in the current mode exhibit D* nearly equal to silicon detectors. Type 4251 solar cells and other similar types exhibit slightly better D* than solar cells with more grids.

Solutions of the fluorescent chemicals Rhodamine, Fluorescene and Eosin produce the highest conversion efficiency of all materials tested but loose this high efficiency when removed from solution. Fluorescent spray paints produce the best results when all factors are taken into account. This is due mostly to the ease in obtaining an even coating. Maximum efficiency is obtained for this application when the fluorescent material is applied directly to the cells.

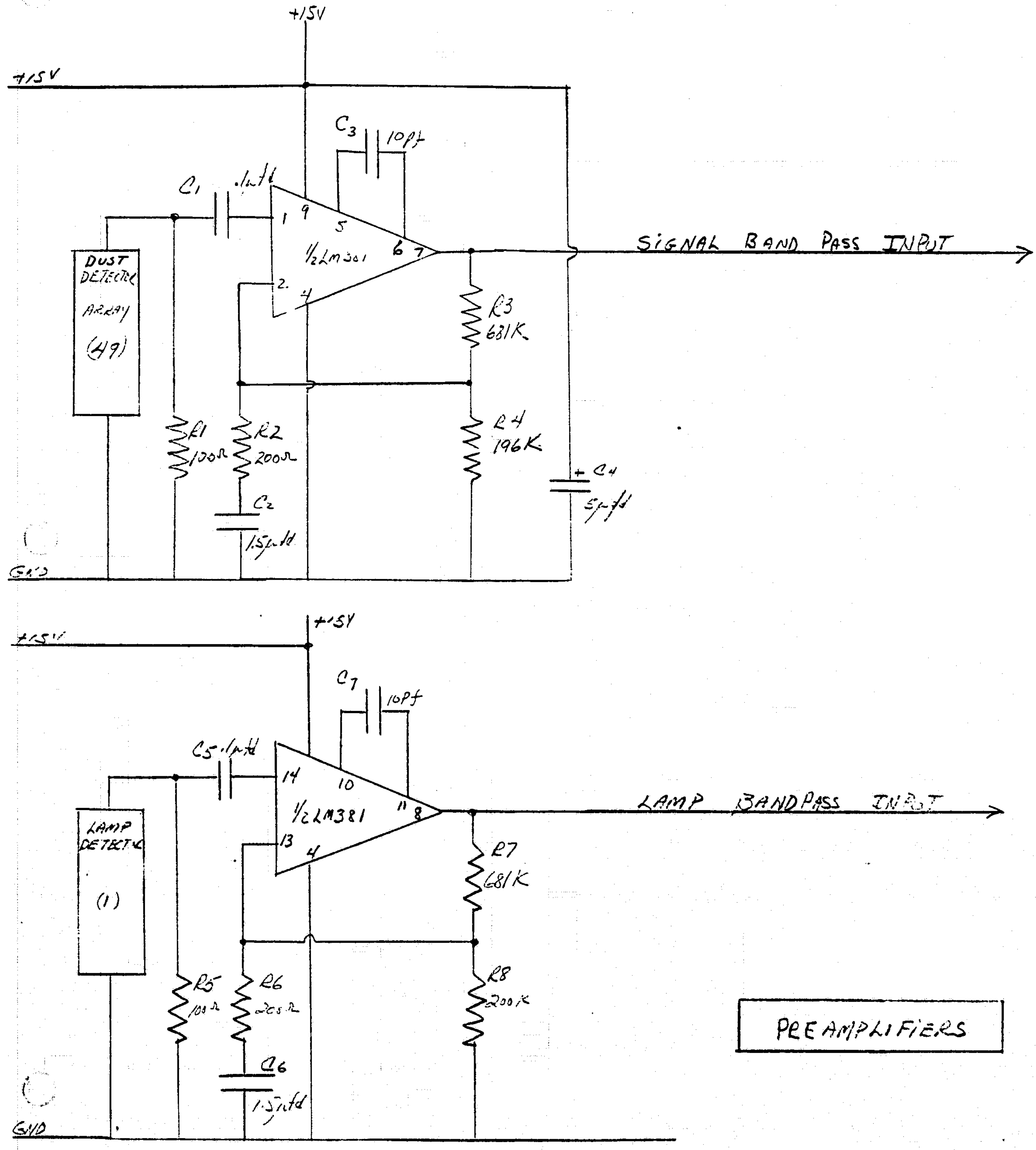
The best way to light two or more gas arc type lamps in sync and to balance their intensity is to fire them in a series configuration. Their intensities can then be balanced by putting a balast resistor across the most intense lamp.

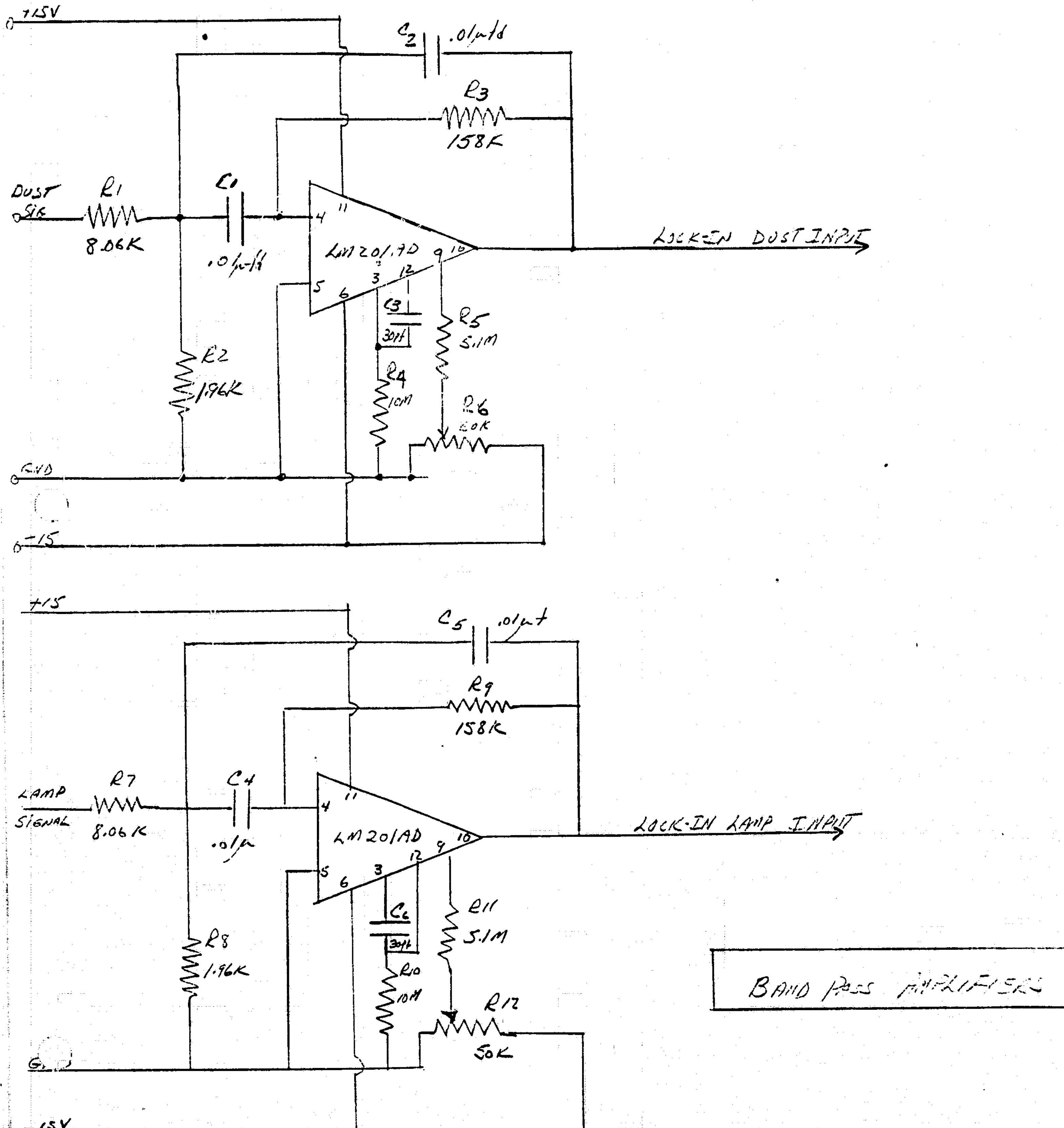
TIME	READING	SENSITIVITY PARTICLES/UNIT	Δ PARTICLES/HR
1805	TURN ON POWER		
1815	558	8.1	
1915	621	8.1	504
2015	632	8.1	89.1
2120	639	8.1	52.3
720	744	8.1	85.1
844	754	8.1	57.8
924	751	8.1	36.4
1029	748	8.1	22.4
1125	730	8.1	162.0
1229	722	8.1	60.7
1324	724	8.1	17.7
1415	719	8.1	47.6
1516	720	8.1	8.0
1620	722	8.1	15.2
1720	725	8.1	24.3
1819	722	8.1	24.4

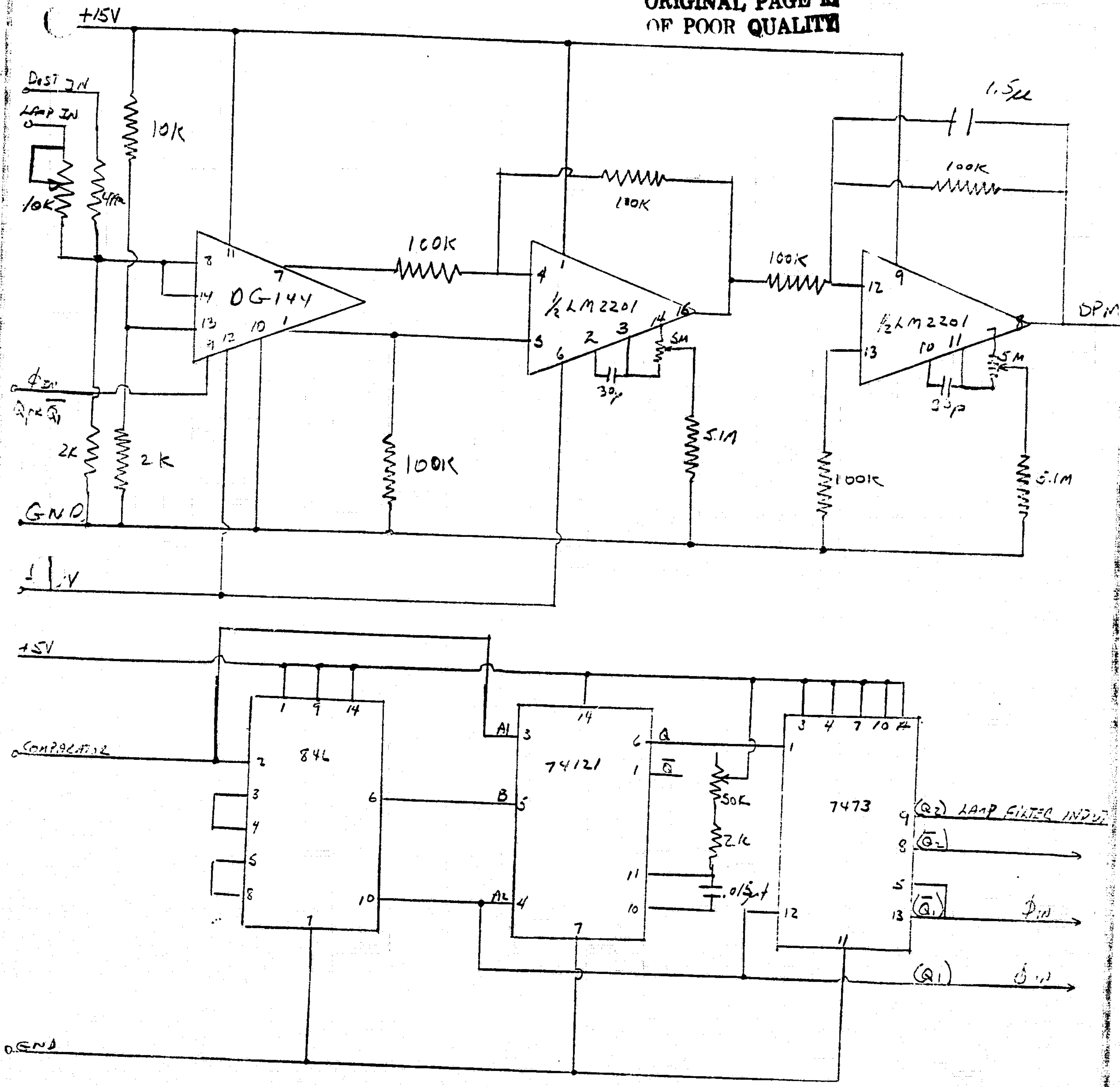
Stability = ΔR x Sensitivity/ΔT = 101 x 8.1/23 = 35 Particles/Hr

TABLE 4. STABILITY DATA

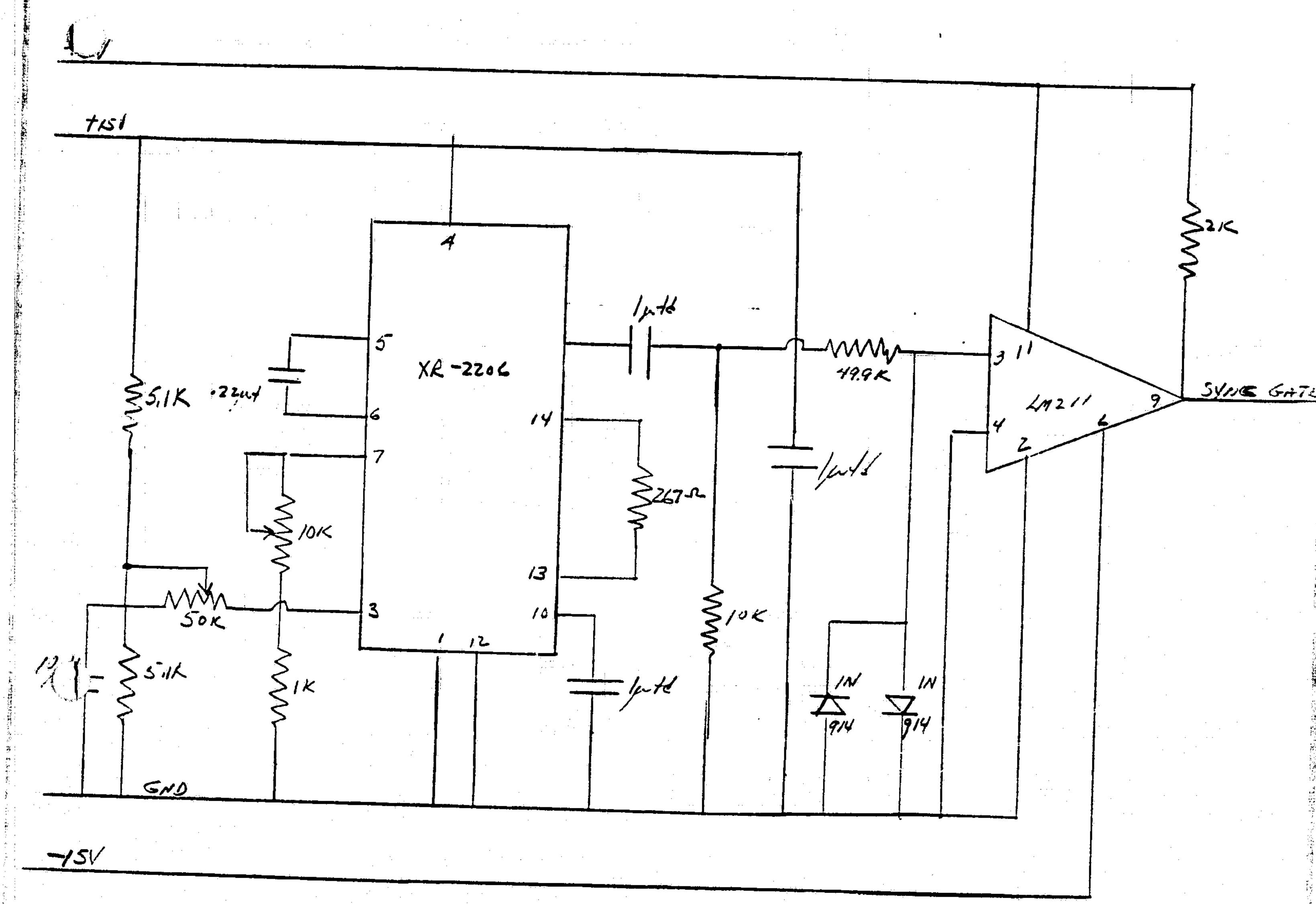
APPENDIX A


+15V
+15V
C_3
10pf
C_1
.1μfd
1
9
5
6
7
½LM381
2.
4
DUST DETECTOR ARRAY (49)
SIGNAL BAND PASS INPUT
R3 681K
R4 196K
R1 100Ω
R2 200Ω
C_2
1.5μfd
C_4
5μfd
GND
+15V
+15V
C_7
10Pf
C_5 .1μfd
14
10
11
8
½LM381
13
4
LAMP DETECTOR (1)
LAMP BANDPASS INPUT
R7 681K
R8 200K
R5 100Ω
R6 200Ω
C_6
1.5μfd
GND
PREAMPLIFIERS

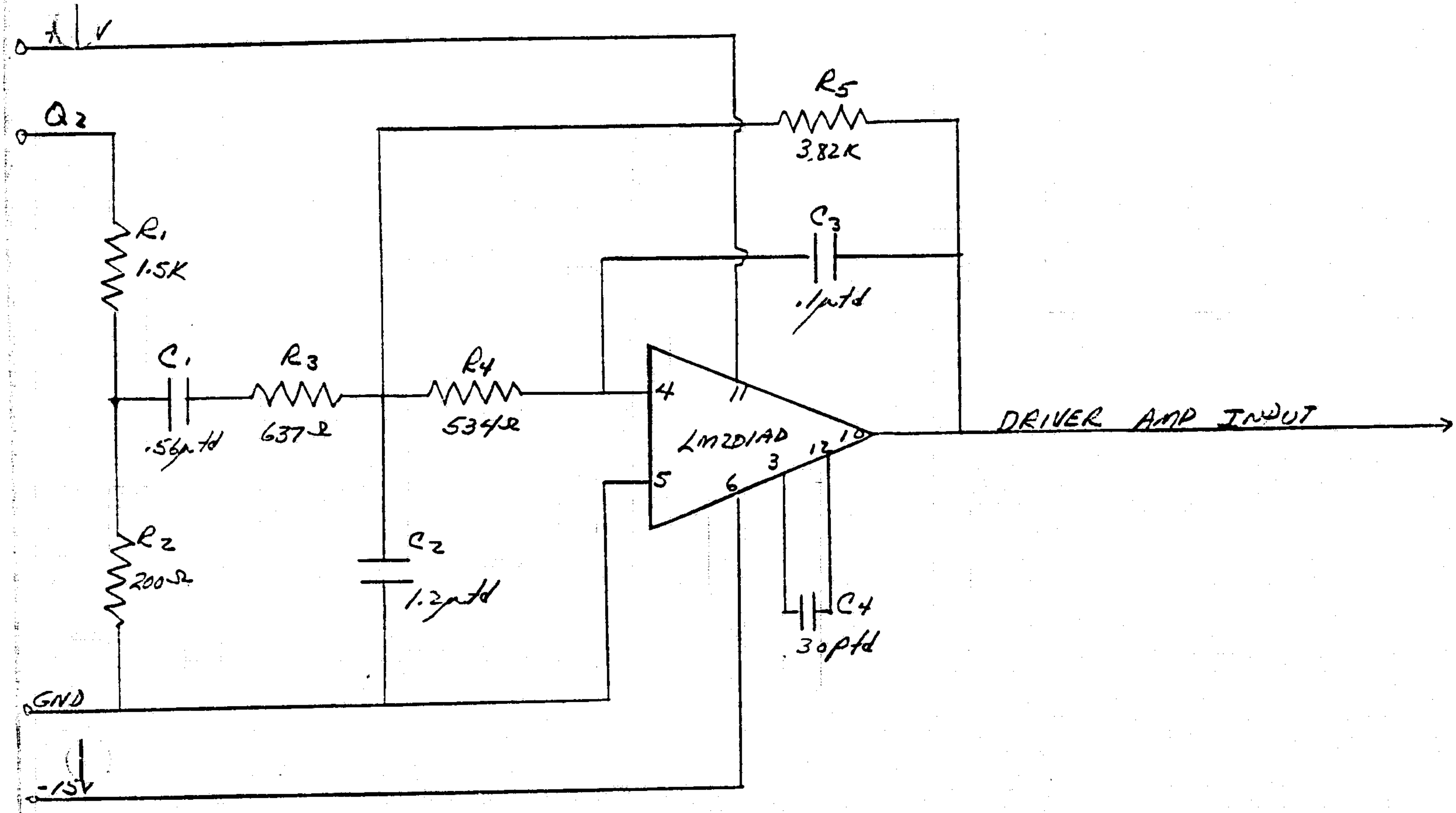

+15V
C2 .01μfd
R3
158K
DUST SIG
R1
8.06K
C1
.01μfd
LM201AD
LOCK-IN DUST INPUT
C3
30pf
R5
5.1M
R2
196K
R4
10M
R6
50K
GND
-15
+15
C5 .01μf
R9
158K
LAMP SIGNAL
R7
8.06K
C4
.01μ
LM201AD
LOCK-IN LAMP INPUT
C6
30pf
R11
5.1M
R8
1.96K
R10
10M
R12
50K
-15V
BAND PASS AMPLIFIER



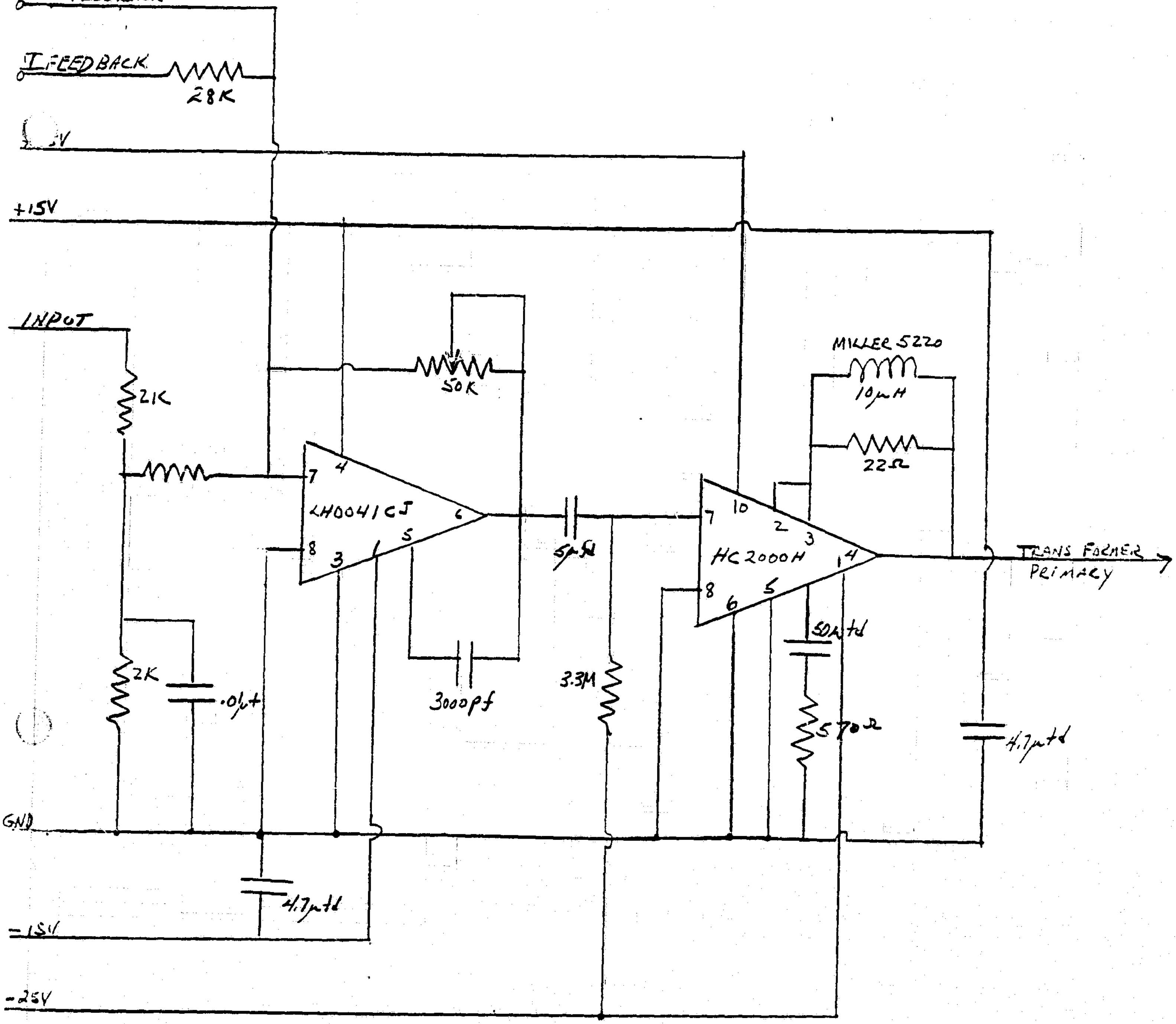
LOCK-IN AMPLIFIER
SYNC GENERATOR
SYNC DIVIDER



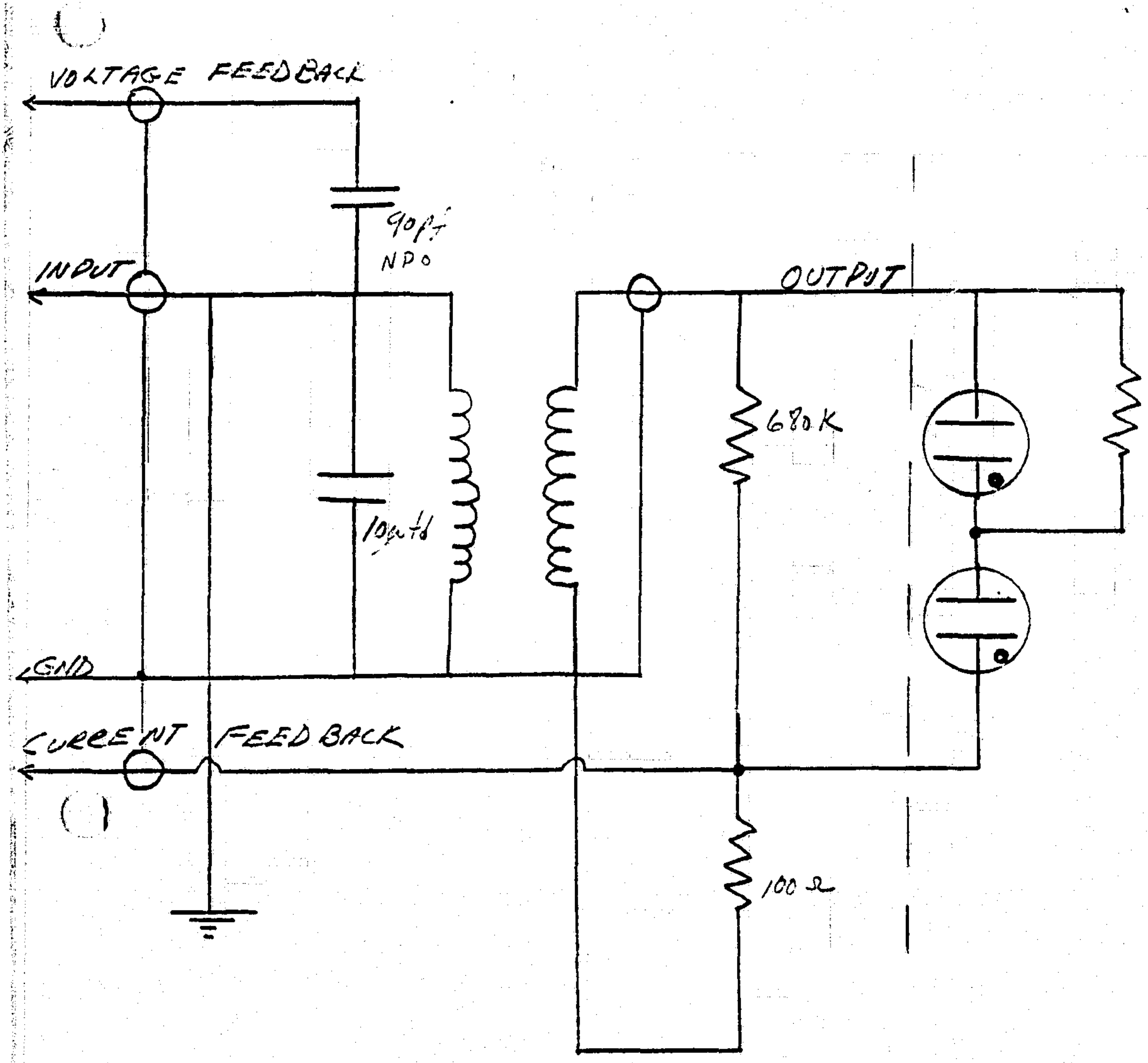
SINE WAVE OSCILLATOR
AND
COMPARATOR



LAMP DRIVER
LOW PASS FILTER



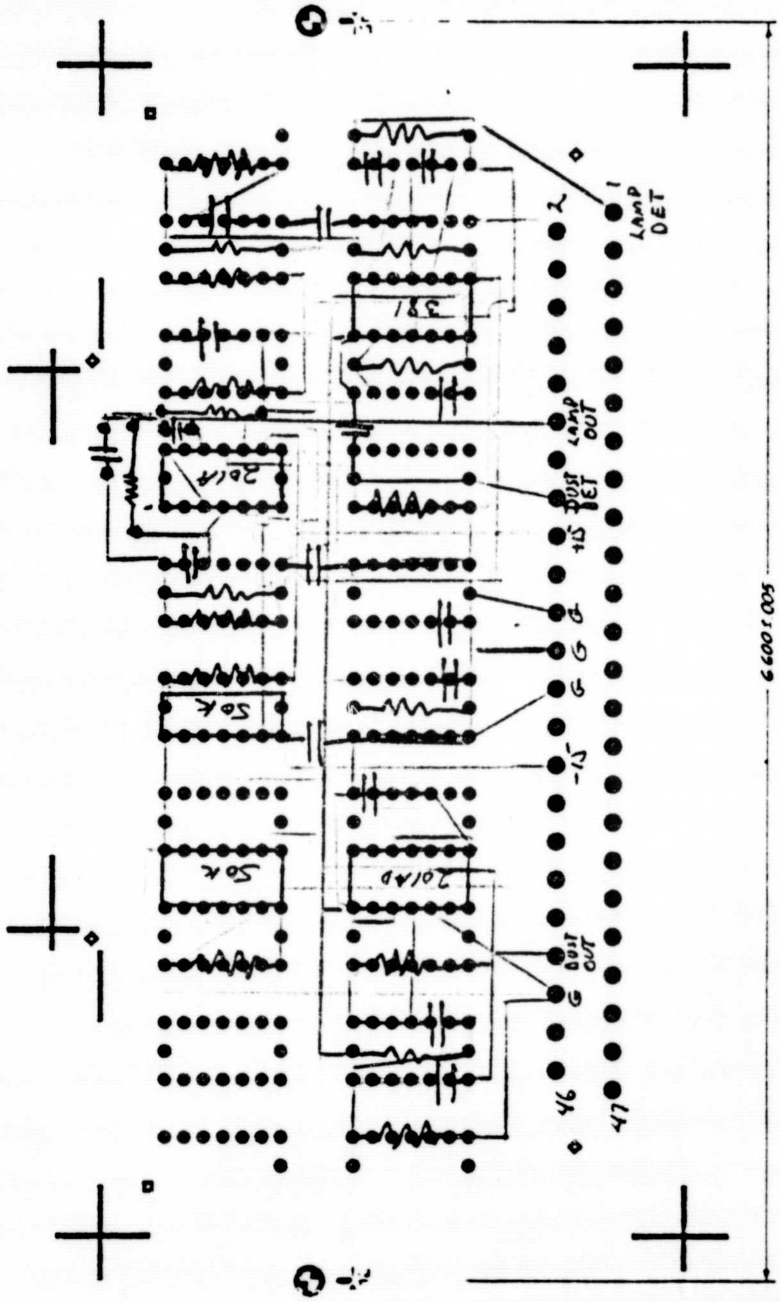
LAMP DRIVER AMPLIFIER



LAMP POWER SUPPLY

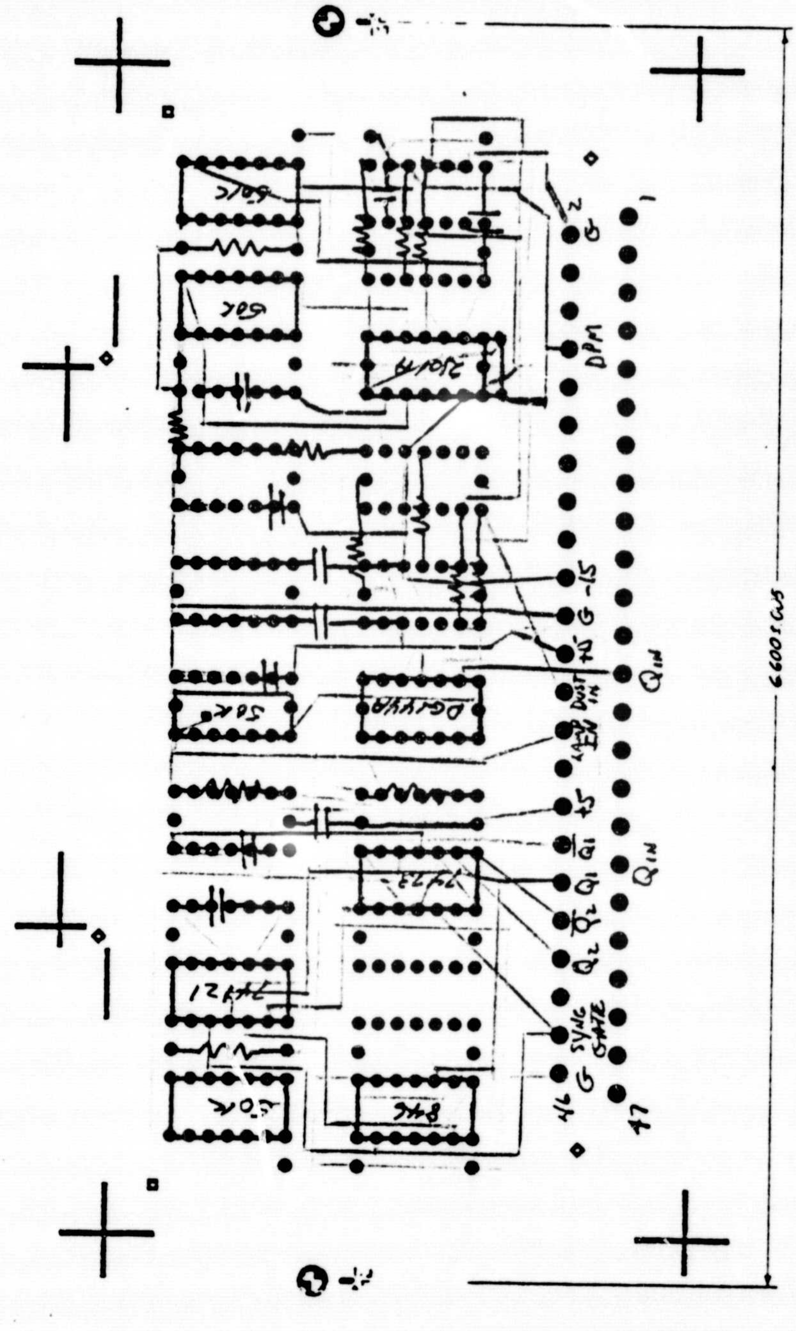
APPENDIX B

BOARD (A)



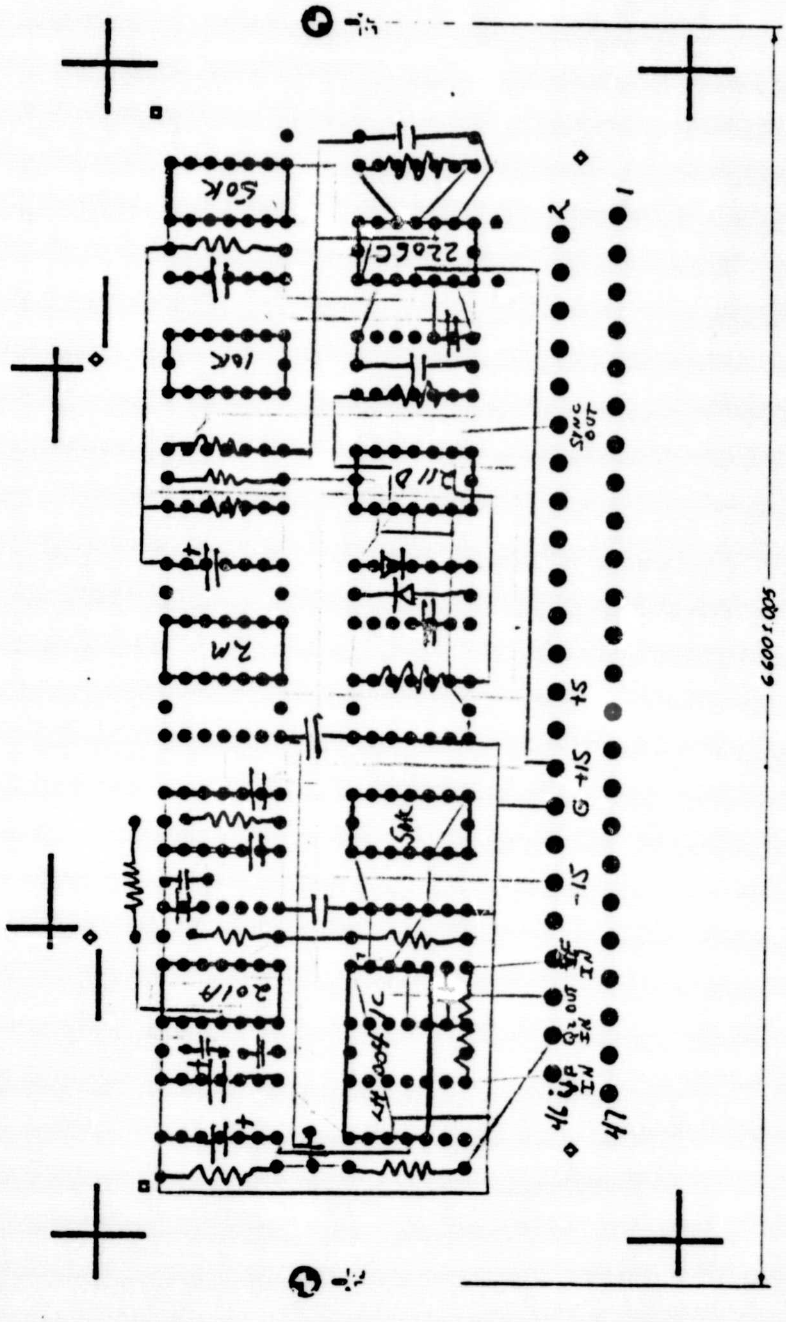
INPUT AMPLIFIERS
BAND PASS FILTERS

BOARD 2



LOCK IN AMPLIFIER
SYNC GENERATOR
SYNC DIVIDER

BOARD (3)



SINE WAVE OSCILLATOR/COMPARATOR
LAMP DRIVER LOW PASS
LAMP DRIVER AMP FIRST STAGE

APPENDIX C

FROM	DESTINATION	NOTES	REMARKS
P1-1	LAMP CELL		LAMP DETECTOR INPUT
-2			
-3			
-4			
-5			
-6			
-7			
-8			
-9			
-10			
-11			
-12	P2-28		LAMP BANDPASS AMPLIFIER OUTPUT
-13			
-14			
-15			
-16	DETECTOR ARRAY		DUST DETECTOR ARRAY INPUT
-17			
-18	PANEL +15V		+15VDC
-19	LAMP CELL		LAMP DETECTOR INPUT
-20	N.C.		GROUND
-21	N.C.		GROUND
-22	ARRAY RET.		GROUND
-23			
-24	PANEL GND		GROUND
-25			
-26	CELL RET.		GROUND
-27			
-28			
-29			
-30	PANEL -15V		-15VDC
P1-31			

CONN. TYPE: ELCO 00-7038-047-000-001

FUNCTION: INTERFACE BOARD 1

CONN. DESIG. P1

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE ——— RELEASED SHEET

REVISION LETTER

FROM	DESTINATION	NOTES	REMARKS
P1-32			
-33			
-34			
-35			
-36			
-37			
-38			
-39			
-40	P2-26		DUST BAND PASS AMPLIFIER OUTPUT
-41			
-42	PANEL GND		GROUND
-43			
-44			
-45			
-46			
P1-47			

CONN. TYPE: ELCO 00-7038-047-000-001

FUNCTION: INTER FACE BOARD 1

CONN. DESIG. P1

REVISION LETTER

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE ——— RELEASED SHEET

FROM	DESTINATION	NOTES	REMARKS
P2-1			
-2	PANEL GND		GROUND
-3			
-4			
-5			
-6			
-7			
-8	J4-1		LOCK-IN AMPLIFIER OUTPUT
-9			
-10			
-11			
-12			
-13			
-14			
-15			
-16			
-17			
-18			
-19			
-20	PANEL -15V		-15VDC
-21			
-22	PANEL GND		GROUND
-23			
-24	PANEL +15V		+15VDC
-25	N.C.		Q IN - SYNC TO LOCK-IN
-26	P1-40		DUST BANDPASS AMPLIFIER OUTPUT
-27			
-28	P1-12		LAMP BANDPASS AMPLIFIER OUTPUT
-29			
-30			
-31			

CONN. TYPE: ELCO 00-7038-047-000-001

FUNCTION: INTERFACE TO BOARD 2

CONN. DESIG. P2

REVISION LETTER

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE ——— RELEASED SHEET

FROM	DESTINATION	NOTES	REMARKS
P2 -32	PANEL 4.8V		+5VDC
-33			
-34	P2 -35		$\overline{Q_1}$
-35	P2 - 34		Q_{IN} - SYNC TO LOCK-IN
-36	N.C.		Q_1
-37			
-38	N.C.		$\overline{Q_2}$
-39			
-40	P3-44		Q_2
-41			
-42			
-43			
-44	P3-12		SYNG GATE
-45			
-46	PANEL GND.		GROUND
P2 -47			

CONN. TYPE: ELCO 00-7038-047-000-001

FUNCTION: INTERFACE BOARD 2

CONN. DESIG. P2

REVISION LETTER

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE —— RELEASED SHEET

C-5

FROM	DESTINATION	NOTES	REMARKS
P3 -1			
P3 -2			
-3			
-4			
-5			
-6			
-7			
-8			
-9			
-10			
-11			
-12	P2-44		SYNC OUT
-13			
-14			
-15			
-16			
-17			
-18			
-19			
-20			
-21			
-22			
-23			
-24			
-25			
-26	PANEL +5V		+5VDC
-27			
-28			
-29			
-30	PANEL +15V		+15VDC
P3 -31			

CONN. TYPE: ELCO 00-7038-047-000-001

FUNCTION: INTERFACE BOARD 3

CONN. DESIG. P3

REVISION LETTER

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE ——— RELEASED SHEET

FROM	DESTINATION	NOTES	REMARKS
P3- 32	PANEL GND		GROUND
-33			
-34			
-35			
-36	PANEL -15V		-15VDC
-37			
-38			
-39			
-40	BNC.-FBK		CURRENT FEED BACK
-41			
-42	HC2000H-IN	TO PIN 7	LAMP DRIVER AMPLIFIER 1 ST OUTPUT
-43			
-44	P2-40		Q2 INPUT TO LAMP BANDPASS AMP
-45			
-46	BNC.-RET		VOLTAGE FEEDBACK
P3 -47			

CONN. TYPE: ELCO 00-7038-047-000-001

FUNCTION: INTERFACE BOARD 3

CONN. DESIG. P3

REVISION LETTER

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE ——— RELEASED SHEET

DCC AUTH FORM 8327

FROM	DESTINATION	NOTES	REMARKS
J4-1	P2-8		DPM INPUT
-2	P2-2, J4-B		DPM SIGNAL RETURN
-3			
-4			
-5			
-6			
-7			
-8			
-9			
-10			
-11			
-12			
-13			
-14			
-15	INPUT PANEL		+5VDC
-A			
-B	J4-2		SIGNAL GROUND
-C			
-D			
-E			
-F			
-G			
-H			
-J			
-K			
-L			
-M			
-N			
-P			
-R			
P4 -S	P.S. COMM.		POWER GROUND

CONN. TYPE: AMPHENOL 225-21521-101

FUNCTION: DIGITAL PANEL METER

CONN. DESIG. P4

SIZE	CODE IDENT	DRAWING NO.
A	14170	

SCALE —— RELEASED SHEET